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G.W.270

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ROYAL AIRCRAFT ESTABLISHMENT
FARNBOROUGH, HANTS

TECHNICAL NOTE No: G.W.270

**A CODED TIME SIGNAL
GENERATOR FOR USE ON
GUIDED WEAPON RANGES**

by

R.J.GARVEY, B.Sc.(Eng.)

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Technical Note No. GW,270

August, 1953

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

A Coded Time Signal Generator for use on
Guided Weapon Ranges

by

R.J. Garvey, B.Sc. (Eng.)

SUMMARY

The equipment is auxiliary to a central timing system which provides common timing and reference signals to all measuring and recording stations on the range. The coder supplies pulses that serve as time markers and indicate the elapsed time, at any instant, with respect to an arbitrary zero, that is the time at which the weapon is fired. The signal is useful where many long runs of recording film are being analysed, since it is not necessary to count up timing marks along the length of the film. It is also useful where recording equipment is switched on after zero time since it still permits the recording to be related in time to that of other range recorders.

The timing pulses are spaced at 0.01 second intervals with a double pulse every 0.1 second. The groups of pulses between the double marks are read as binary numbers which indicate the number of tenth seconds that have elapsed to the preceding 0.1 second markers. Elapsed time can thus be read to within less than 0.01 seconds. The coder normally counts up to 51.1 seconds and then recycles; it can, however, be readily adapted to have a counting capacity of 511 seconds.

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1 Introduction

The equipment has been designed as an addition to the central timing system used on the guided weapons range at Larkhill¹. This system, which is described briefly in the following two paragraphs, is illustrated by Fig.1; the coded time signal generator being shown as a "Coder".

The complete timer supplies timing and reference signals to the various recording instruments and stations on the range; the signals being transmitted to the remote stations via underground cables. The system consists of a 10 Kc/s oscillator and a series of frequency dividing circuits which feed pulses at various frequencies to a number of output channels. A gate circuit in each output channel is normally opened when the weapon is launched, so that the start of the transmission is a zero time. Transmission before zero time can be effected by manual operation of the gate and the zero pulse which triggers the gates can also be selected and transmitted as a timing signal. It is important that zero time be recorded in some way on all the range recording instruments during a shoot, since it permits the data obtained from them to be co-related in time.

A useful output is provided by a mixer. This supplies a "Ruler Time Scale" consisting of pulses at a 1,000 p.p.s. with marking pulses superimposed at 100, 10 and 1 p.p.s. The zero pulse appears as a step in the composite waveform.

The function of the Coder is to supply pulses that will serve as time markers and also indicate the elapsed time, at any instant, with respect to the zero pulse. This signal is particularly useful where many long runs of recording film or paper are being analysed, since it is not necessary to count up timing marks along the length of the film. The Ruler Time Scale is useful in this respect but with this it is still necessary to count the 1 p.p.s. markers. A coded time scale is also useful where recording equipments, such as target cameras, are switched on after zero time. It is not possible to record a zero mark under these conditions; a coded time scale is therefore required so that the recording can be related in time to that of other range recorders.

The timing pulses supplied by the coder are shown by Fig.7. These pulses are spaced at 0.01 second intervals with a double pulse every 0.1 second. The groups of pulses between the double marks are read as binary numbers; a positive pulse being 1 and a negative pulse 0. The binary number indicates the number of tenth seconds that have elapsed up to the preceding 0.1 second marker.

An alternative display is shown by Fig.8. Here positive and negative pulses are replaced by dots and dashes; a dash being read as 1 and a dot as 0.

2 General Description

The general arrangement of the coder is illustrated by Fig.2. Pulses at a frequency of 10 p.p.s. are fed via a gate to a nine stage binary counter. Each stage is a valve having two stable states i.e. an On and an Off position. They are connected in series so that successive stages are switched on and off at intervals of 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 12.8, and 25.6 seconds. An electronic switch is driven at a 100 steps per second so as to scan the counter once after each counter operation. This switch delivers an output pulse each time it sweeps across a counter stage that is "On"; stages that are "Off" giving no response.

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The signal from the scanner is fed to a mixer circuit where it is mixed with 10 and 100 p.p.s. signals to provide the required coded output. The mixing is illustrated by the waveforms of Fig.6. The positive pulses from the scanner are twice the amplitude of the 100 p.p.s. pulses so that the two signals add to produce a positive pulse in the mixer output. The 10 p.p.s. signal is fed to the mixer via a delay circuit; it is then out of phase with the 100 p.p.s. signal and so produces double pulses in the output. Normally all pulses in the coder circuits are in phase since they are derived from the common 10 Kc/s oscillator and dividing circuits of the timing system.

The interpretation of the coded output signal follows from the fact that positive pulses indicate that certain binary stages are switched on at a particular instant; the position of the pulses with respect to the 0.1 second marker indicating which stages are concerned. Thus the groups of pulses between the double marks can be read as binary numbers which indicate the elapsed time to each 0.1 second marker. The elapsed time is measured from the instant at which the gate precoding the binary counter is opened; This gate is opened by a pulse coincident with zero time for the complete timing system. Closing the gate at the end of the run resets the counter to the zero condition, all the binary stages being switched to the off position.

The negative pulses shown in the output waveforms are not strictly necessary for interpreting the code since the absence of a pulse could be read as 0. However the absence of these pulses would result in long gaps in the time trace. The record would not be so convenient to read and interpolation would be necessary to measure to 0.01 seconds.

The scanner can be regarded as a ten way rotary switch driven at 10 revolutions or 100 steps per second, so that it rotates in synchronism with the 10 p.p.s. signal to the counter. Nine outlets of the switch are connected to the counter, the tenth being unused and serving as an idle position. A 10 p.p.s. signal phases the operation so that the switch reaches the idle position each time the counter is operated. This phasing ensures that a complete and successive scan of the binary stages is made after each counter operation.

With the arrangement described the coder counts up to 51.1 seconds and re-cycles. This meets most requirements at the range for which this equipment was designed since the flight time of weapons fired there rarely exceed 30 seconds. The coder can however be used to count seconds rather than tenth seconds when the counter will have a capacity of 511 seconds.

The output signal from the coder is transmitted via underground cables to the remote stations where it is normally displayed as a time trace on C.R.O. recorders. With some recording equipment it is more convenient to record the time trace with a neon or argon filled flash lamp. The positive and negative pulses cannot be recorded as such on a single lamp so they are converted to square pulses which operate the lamp to produce a dash-dot time trace as shown by Fig.8. Fig.9 is a typical application where a dash-dot trace is recorded along the edge of a cine camera film. It is not practical to transmit the square pulses along the underground cables without excessive distortion; the conversion is therefore made by a small unit local to the particular recording equipment.

3 Circuit Details

3.1 Pulse Shapers

These circuits which are detailed on Fig.3 shape the 10 p.p.s. and 100 p.p.s. pulses supplied from the external timing system, so that they

are suitable for operating the counter and scanner, both of which require fast, well defined waveforms. They also feed suitably shaped pulses into the mixer circuit.

The negative 10 p.p.s. pulses are fed to the grid of V1A. This is positively biased so that it clips any small amplitude unwanted signal from the input. The amplified pulses from V1A trigger a flip-flop²; fast square waves being available at the anode of V2B. The diode connected to the grid of the flip-flop removes any negative component of the signal while the 220 pf condenser renders the flip-flop insensitive to any induced h.f. transients. The square waves at V2B are differentiated and fed to the amplifiers V3A and V3B which supply pulses to the counter and scanner. These amplifiers are biased so as to clip off the negative pulses corresponding to the trailing edge of the flip-flop square waves. The 150 K resistor at the anode of V2B prevents the capacitive load of V3B spoiling the fast waveform required by the counter.

Negative square waves available at the anode of V2A are fed to the shaper V5. Here the square waves are differentiated and the negative pips removed by the diode V4. The 10 p.p.s. pulses at the anode of V4 coincide with the trailing edge of the square waves from V2A and they are therefore 3 milliseconds out of phase with the other 10 and 100 p.p.s. pulses. This circuit thus corresponds to the 3 millisecond delay unit shown on the block diagram of Fig.2. The network and diode connected to the anode of V5A differentiate and clip the output pulses again so that a suitably shaped signal is available for feeding to the mixer.

The 100 p.p.s. pulses are amplified by V6A and trigger the flip-flop V7 as for the 10 p.p.s. signal. The square waves at the anode of V7B are differentiated and the negative pulses shorted by V8. The remaining positive pulses trigger a second flip-flop V9 which provides the 40 micro-second pulses for driving the scanner. These pulses are available at the anode of V9B where they have a peak amplitude of about 200 volts; they are fed to the grid of V10A which is biased to clip the top and bottom off the input square waves and so provide faster square pulses. The amplifier also inverts the flip-flop output; negative pulses being required to drive the scanner.

The output at the anode of V7B is also fed to V11A which functions as an inverter so that negative going square waves are available at the anode. The square waves are differentiated and the positive pulses removed by V11B. The remaining negative pulses are fed to the mixer.

3.2 Counter

This circuit which is shown on Fig.4 is a conventional nine stage binary counter². Each stage consists of a double triode and has two stable states in each of which one triode section is conducting while the other is cut off. The binaries can be switched from one state to the other by feeding a negative pulse via a common anode connection to the grids of the two triodes. The stages are connected in series so that two operations of any stage will trigger the succeeding one.

In the reset condition the left hand resistance chain of each binary is connected via a common rail and 4,700 ohm resistor to earth. This raises the grid potential of the right hand triodes so that they remain in the conducting condition with the left hand triodes cut off; the 10 p.p.s. input signal is then ineffective. The counter starts to operate at zero time when a high speed relay switches the reset rail to earth via plug D. This starting circuit is effectively the gate shown on the block diagram of Fig.2.

The neon lamps connected to each binary are mounted on the front panel of the equipment and give a useful indication of the counter operation. They are switched on and off by each binary stage.

3.3 Scanner

This circuit is shown on Fig.4. The scanner consists of a cold cathode glow discharge tube³. It has an anode and shield, with ten cathodes and ten transfer electrodes arranged alternately around the circumference; the transfer electrodes being connected together. The anode to cathode discharge is switched successively to each cathode by suitable trigger pulses applied to the transfer electrodes. The transfer electrodes are supplied in this case with a 100 p.p.s. signal so that the discharge rotates at a 100 steps or 10 revolutions per second.

Negative pulses at a frequency of 10 p.p.s. and coincident with those operating the counter are fed to the tenth cathode shown on the extreme right of the diagram. This over-rides the normal operation and pulls the discharge to this cathode if it does not happen to be there when the counter operates. This phases the scanner so that a complete and successive scan is made after each counter operation. This phasing comes into effect when power supplies to the circuits are first switched on, the phasing facility is then superfluous since the scanner rotates in synchronism with the counter until the equipment is switched off.

The discharge current flowing successively through the 15,000 ohm resistors produces 10 p.p.s. pulses at each scanner cathode. The nine cathodes are connected respectively to the nine counter stages via a condenser and resistance chain. Typical waveforms for one of these connections are shown. The square pulses at the cathode are differentiated and added to a platform voltage from the counter stage. The resulting waveform (d) is fed via a diode to a common output rail. This diode is biased, by a d.c. voltage on the rail, so that pulses from the scanner cathode are only fed out when the particular counter stage is switched on. The pulses from each scanner - counter connection are fed via diodes to the common rail. The resulting output is a train of pulses; the phase of each pulse showing which counters are switched on during each sweep of the scanner. A typical output for two successive scans is shown by Fig.6.

The 250,000 ohm preset resistors in each resistance chain are used to adjust the signal amplitudes with respect to the bias voltage and thus balance out inequalities of valve characteristics and resistance values.

3.4 Mixer

This circuit is detailed by Fig.5; its function is to mix the 10 p.p.s., 100 p.p.s. and coded signal from the scanner to provide the final output as shown on Fig.6.

The pulses from the scanner are first shaped by V12A and V12B. The first section amplifies the pulses and feeds them to the grid of the second which is biased to clip the top and bottom off the pulses. Fast, flat topped pulses are thus available at the anode of V12B; these are differentiated, the negative pip removed with a diode and the positive one fed to the mixer.

The 10 p.p.s., 100 p.p.s. and coded signal are added at the grid of V14A which functions as a low gain amplifier; an anode to grid circuit providing negative feed back. The signal is then fed to V14A a cathode follower, the final output signal being available at plug H.

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The positive pulses from the scanner are twice the amplitude of the negative 100 p.p.s. pulses so that the two signals add to produce positive pulses. The shaping networks connected to the anodes of V5A and V11A ensure that the two sets of pulses have the necessary similar waveforms. Slight discrepancies in the waveform and phasing of the pulses are corrected by the condensers connected to the grids of V11A and V14A. The code pulses from the scanner are adjusted to the necessary amplitude by a 500,000 ohm preset resistor in the grid circuit of V14A. The 10 p.p.s. signal is out of phase with the others and so produces double markers in the output which bracket the pulses into groups of nine. The relative position or phase of the positive pulses in each group indicate which stages of the counter are on at that instant. The groups can be read as binary numbers which indicate the elapsed time in tenth seconds to the preceding tenth second markers.

3.5 Monitoring Facilities

The functioning of the equipment can be monitored by observing the display given by the scanner valve and the operation of neon lamps connected to the counter. In addition key points in the circuit are wired, via isolating resistors where necessary, to monitoring tag boards on the front panels of the equipment. The operation of any part of the circuit can be checked by connecting a C.R.O. to these monitoring terminals. These monitoring connections together with normal waveforms at each point are shown on Figs.3 and 4.

4 Local Time Coder

As mentioned above it is convenient with some range equipment to record the time trace on a single neon or argon filled flash lamp. The positive and negative pulses of the coded signal are therefore converted to square pulses which operate the lamp to produce a dot-dash time trace. It is not practical to transmit the square pulses along the underground cables to the remote recorder without excessive distortion; the conversion is therefore made by a small unit local to the recorder.

The circuit of this unit is detailed by Fig.5. As with most transmissions on the range cables the signal is transmitted along a pair of lines terminated in transformers at each end which balance the lines about earth to eliminate cross-talk from other circuits in the cable. In this particular case the equipment side of the receiving end transformer is also connected as a phase splitter so that a given signal pulse appears with opposite polarities at the grids of V1A and V4A.

The signal is amplified by V1A and fed to V1B which is biased to reject positive and amplify negative pulses. The positive pulses from the anode of V1B trigger the flip-flop V3; this valve provides square pulses, each of 4 milliseconds duration, corresponding to the positive pulses fed to the grid of V1A. The circuit consisting of valves V4, V5 and V6 functions in a similar manner to that just described. It operates however on pulses of opposite polarity, as seen on the line, and the flip-flop V6 produces square waves of only 1 millisecond duration.

The square waves from V3B and V6B are added and fed to the grids of the output valves V7A, V8A and V9A. These amplify the signal so that it operates the neon or argon filled recording lamps. The 6.8 MΩ resistors keep the lamps ionized which improves the speed and reliability of their operation. The diodes V7B, V8B and V9B isolate the driving and ionizing circuits. This unit will operate timing lamps for three recorders and provision is made on the chassis for mounting additional output valves if required.

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Typical input and output waveforms are shown on the diagram; the wide square waves corresponding to negative and the narrow ones to positive input pulses. The time trace produced by the neon lamps is shown on the records of Figs.8 and 9; the latter being a high speed cine camera film.

Key points in the circuit are wired to a tag board on the front panel of the unit so that the operation can be readily checked with a C.R.O.

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<u>No.</u>	<u>Author</u>	<u>Title, etc.</u>
1	R.J. Garvey	Central Timing Equipment, G.W. Range, Larkhill. R.A.E. Technical Note No. G.W.67. February, 1951.
2	B. Chance and Others	Waveforms, Chapter 5, McGraw Hill Book Co. 1949.
3	G.H. Hough and D.S. Ridley	Cold Cathode Glow Discharge Tubes, Part 3. Electronic Engineering, 24. 292, 1951.

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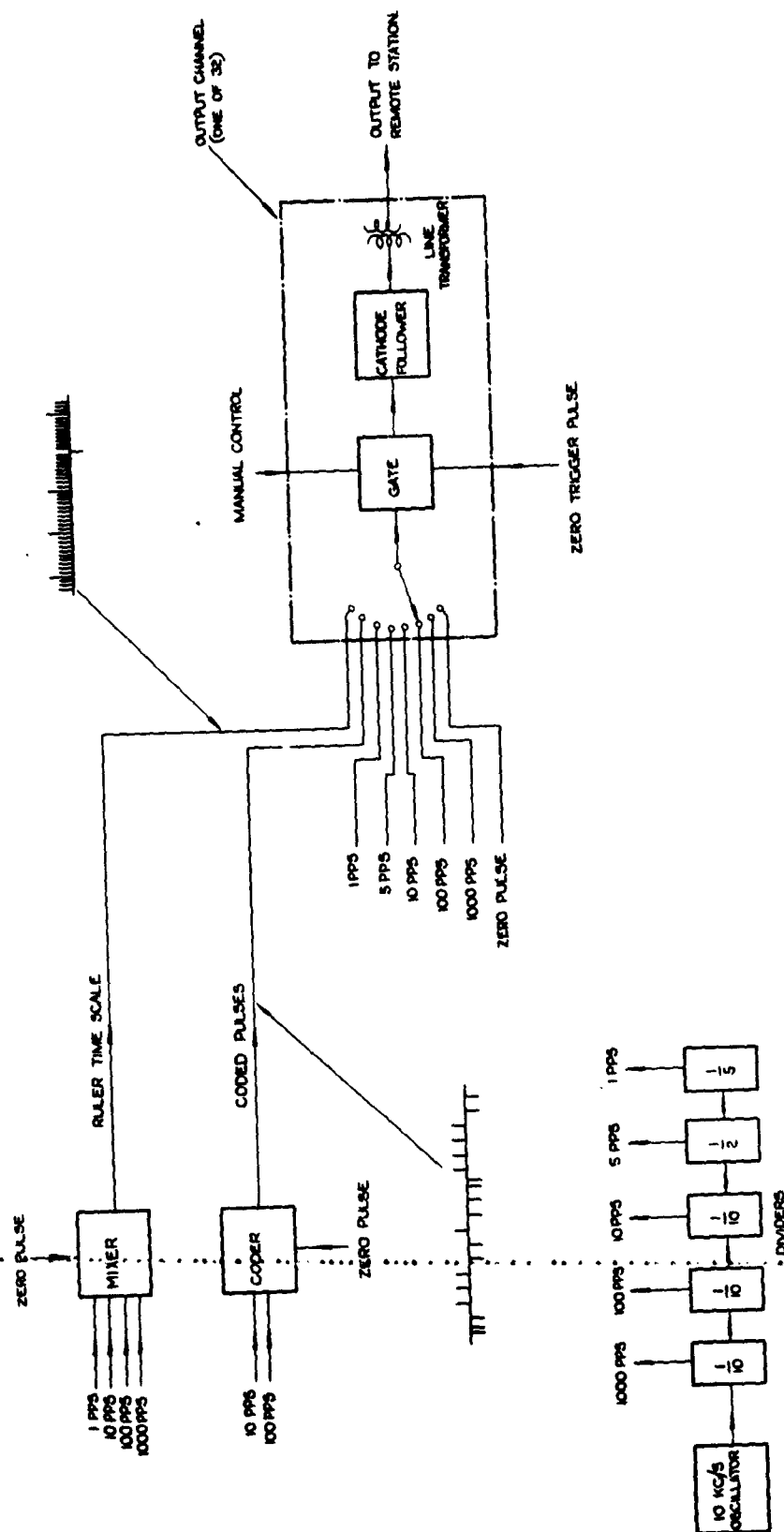


FIG.1. BLOCK DIAGRAM OF CENTRAL TIMING EQUIPMENT.

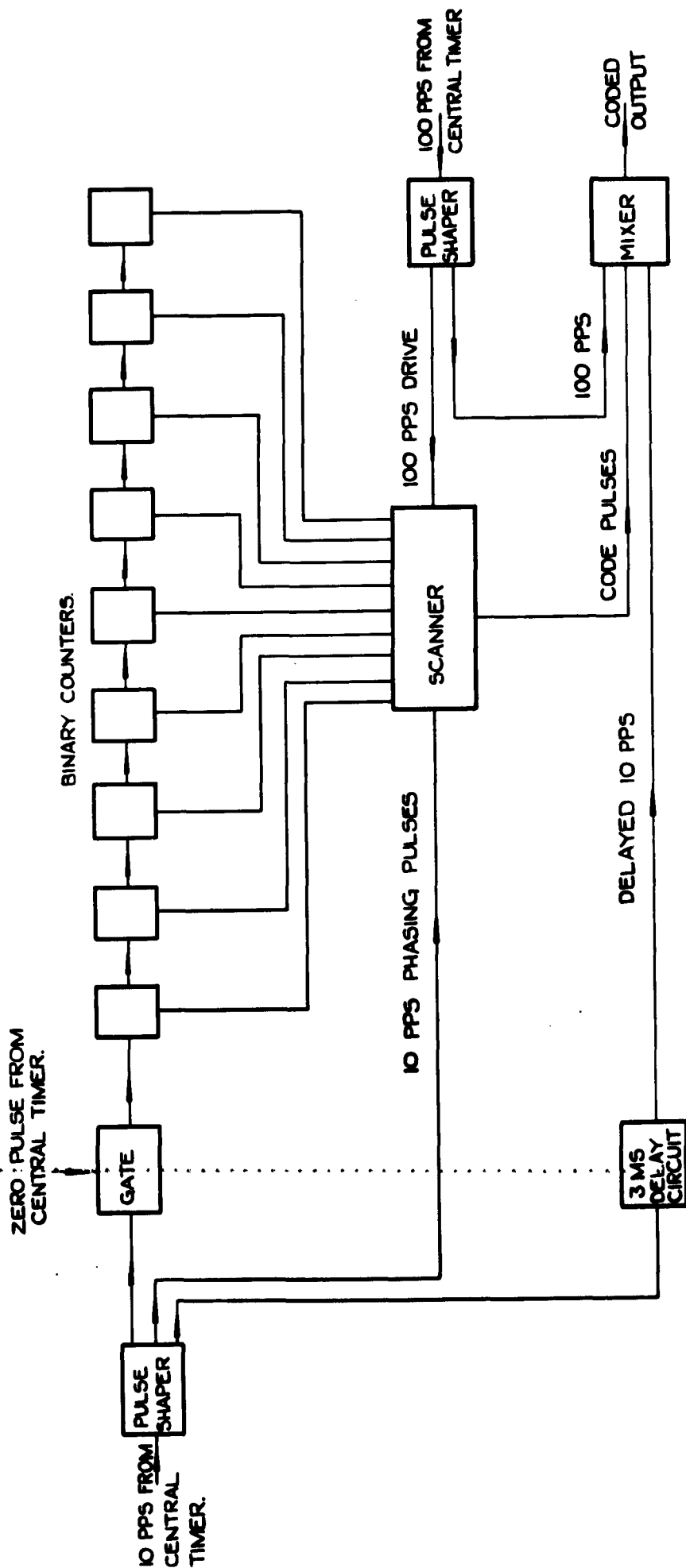


FIG.2. BLOCK DIAGRAM OF CODED TIME SIGNAL GENERATOR.

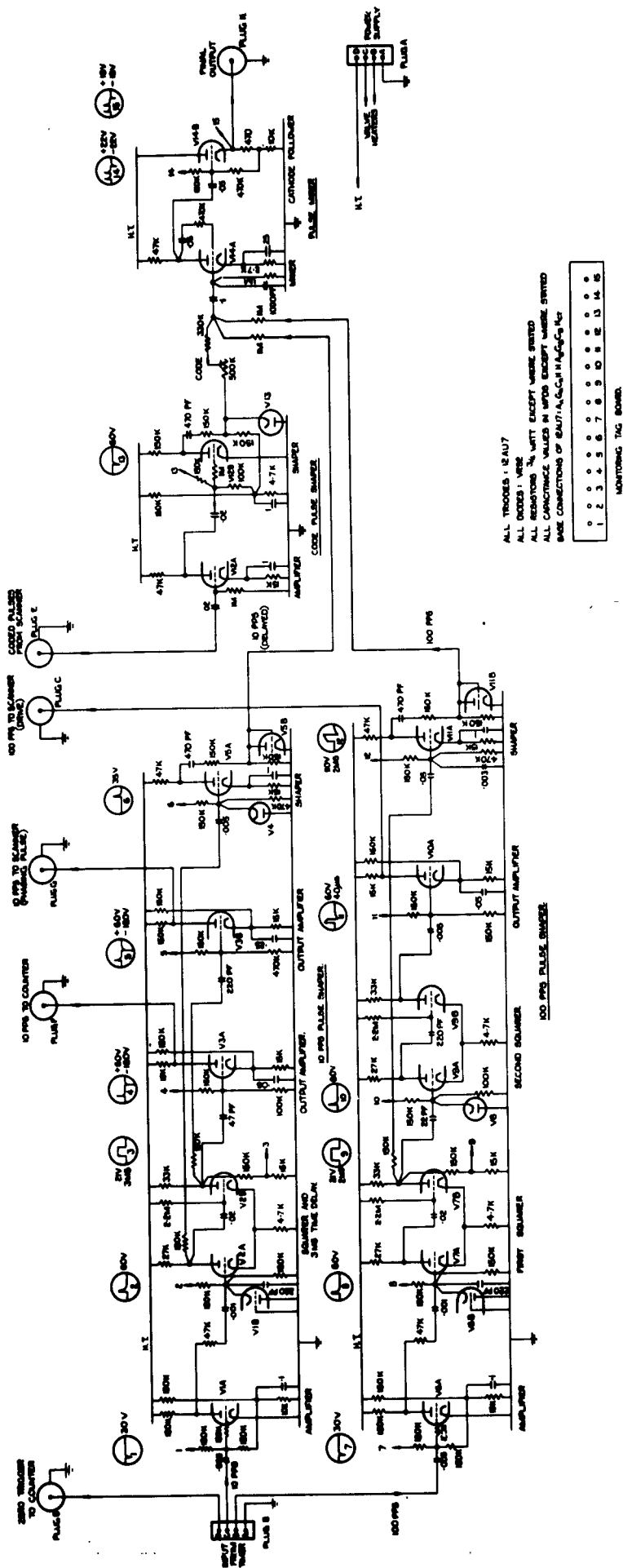


FIG.3 WIRING DIAGRAM OF PULSE SHAPERS & MIXER.

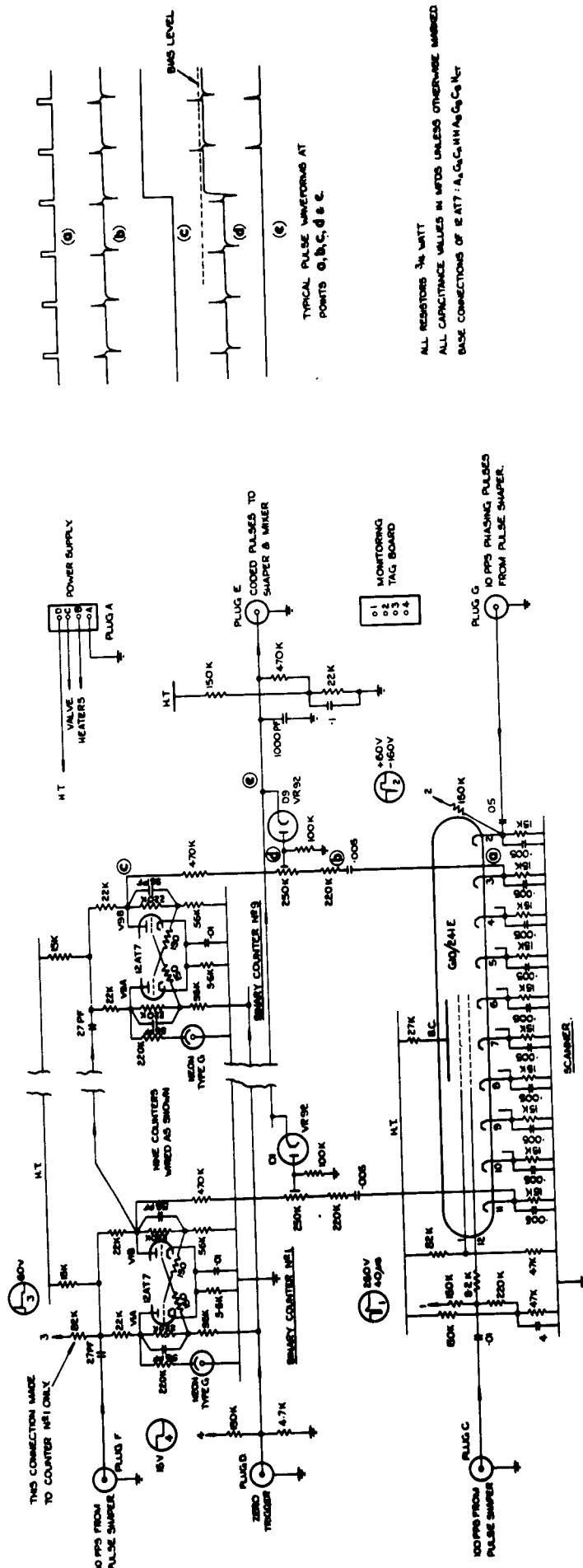


FIG.4. WIRING DIAGRAM OF BINARY COUNTER & SCANNER.

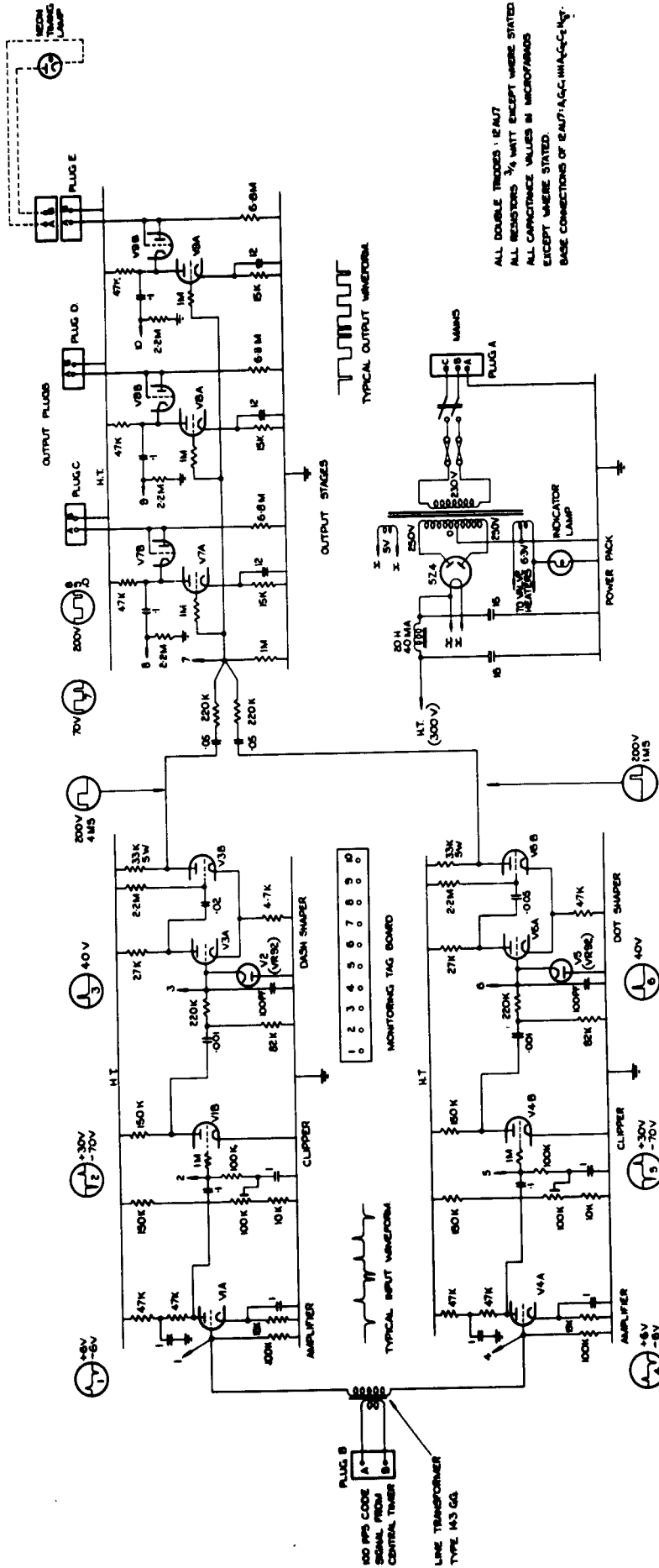


FIG.5. WIRING DIAGRAM OF LOCAL TIME CODER.

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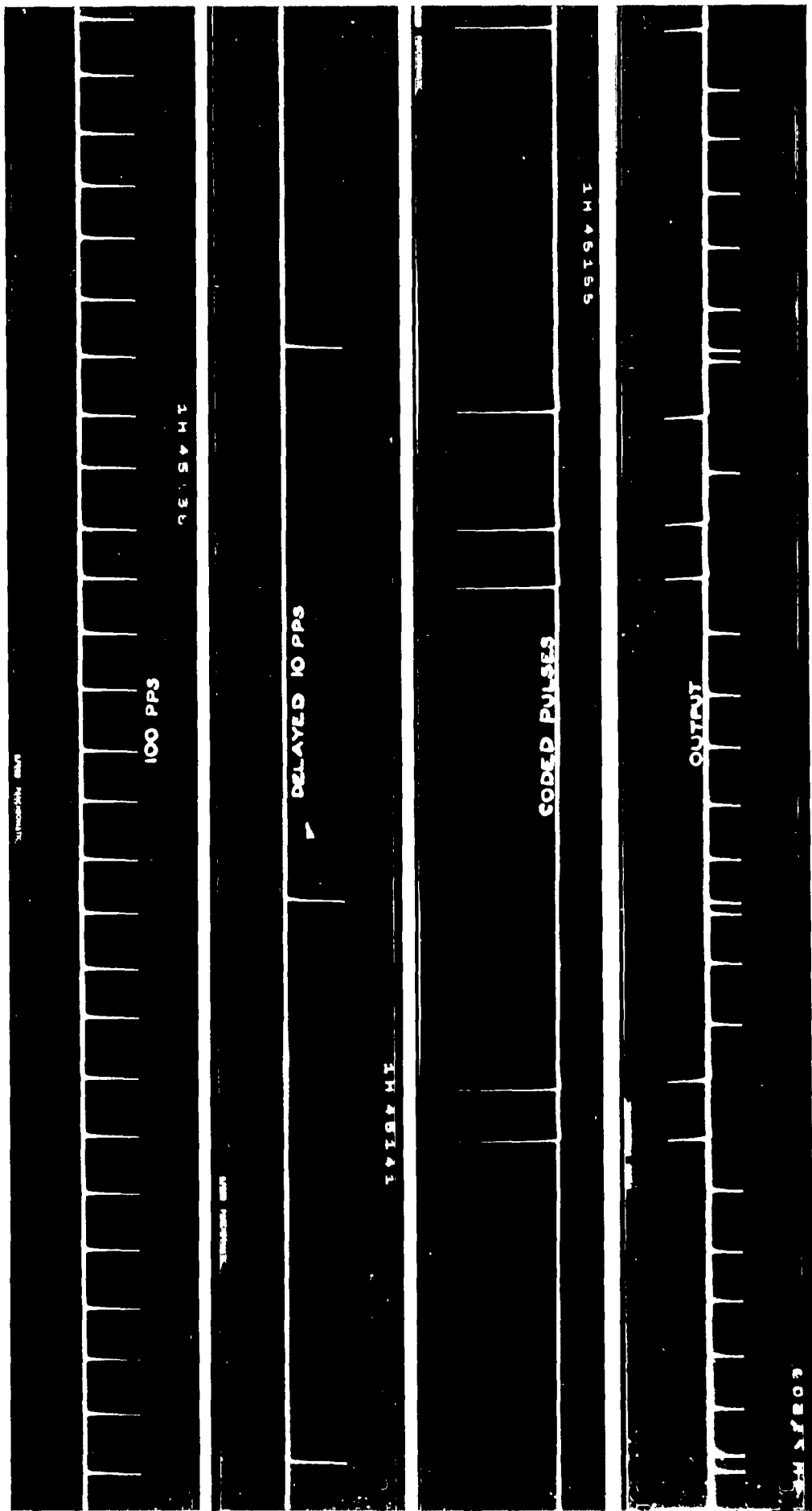


FIG.6. WAVEFORMS IN MIXER CIRCUIT

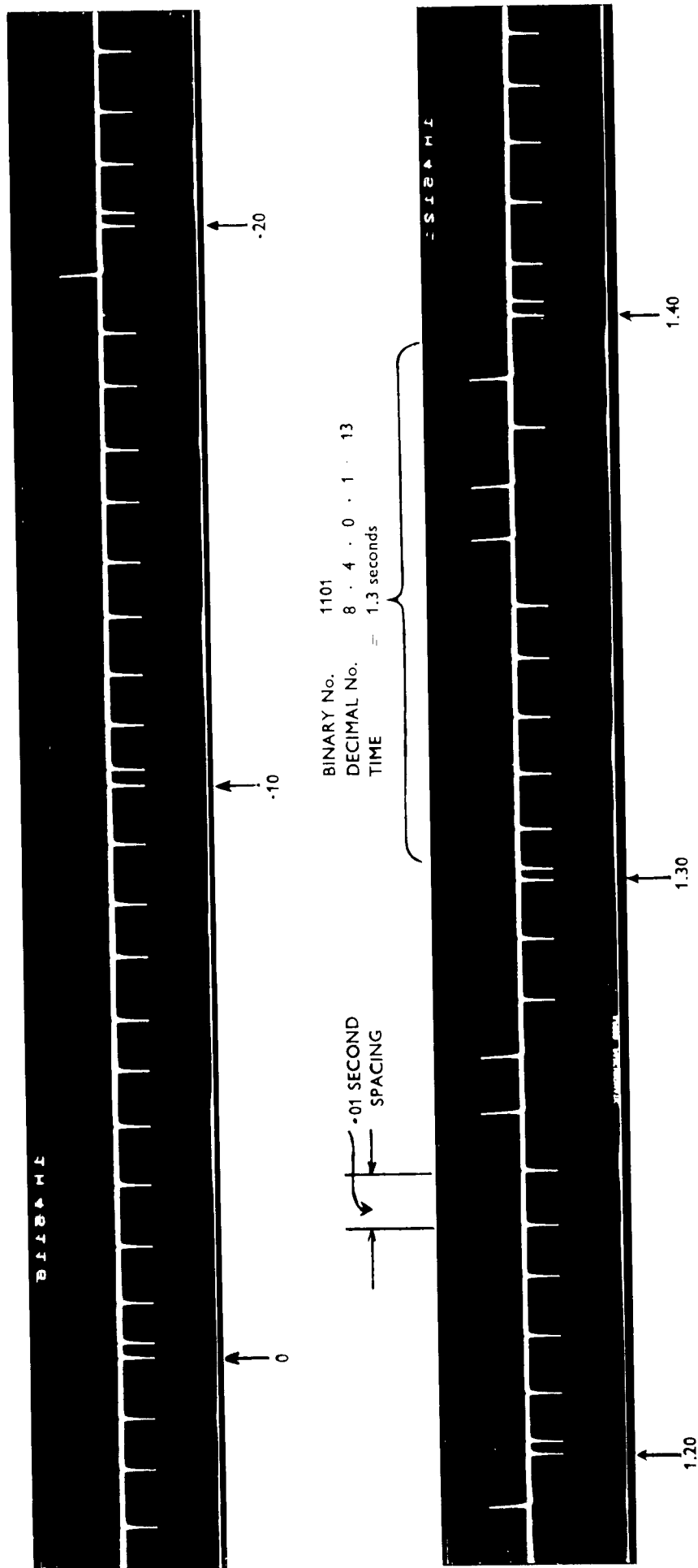


FIG.7. TYPICAL OUTPUT WAVEFORMS

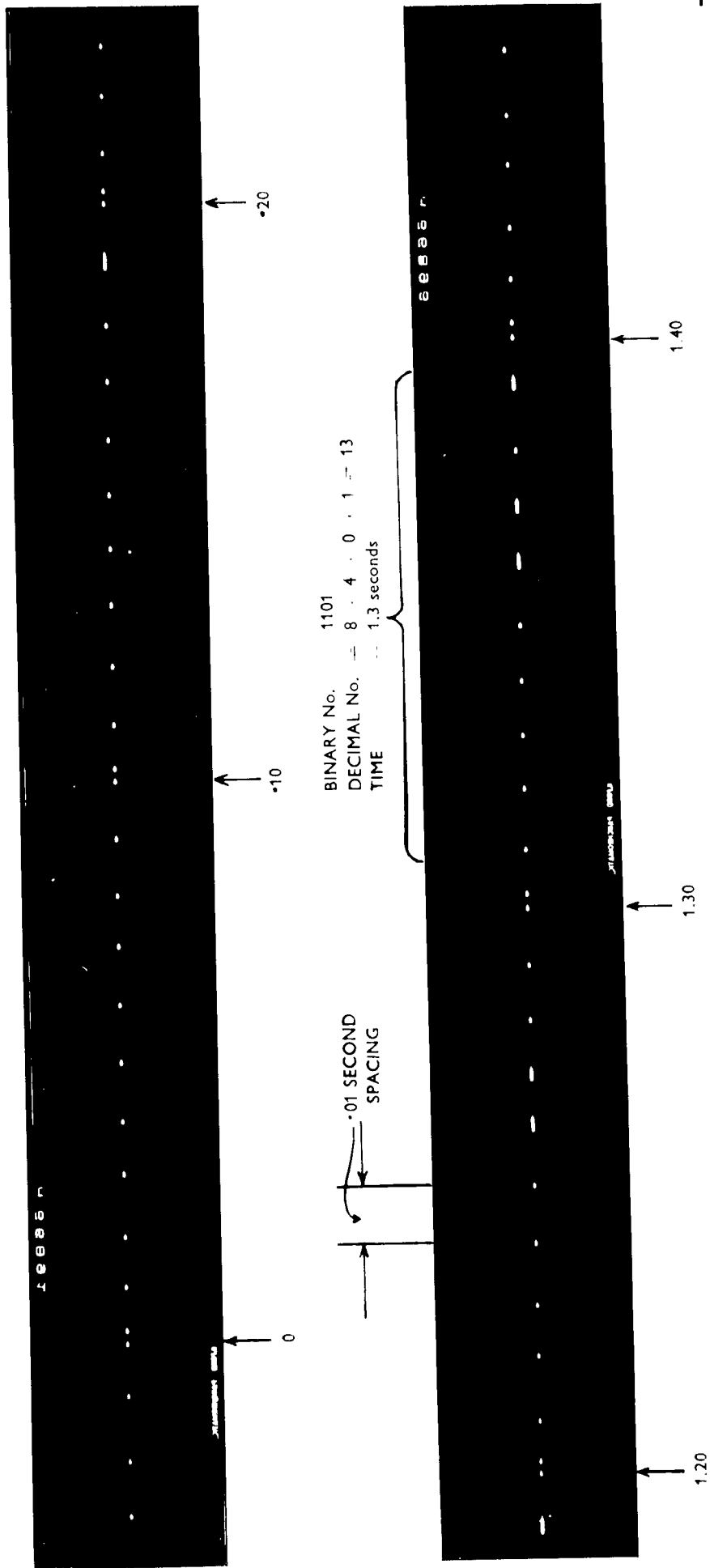


FIG.8. TYPICAL DOT-DASH RECORD

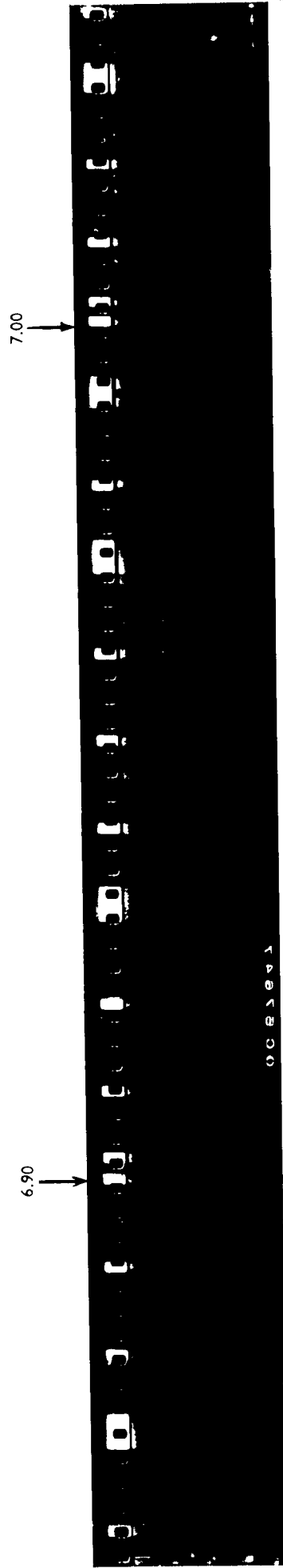
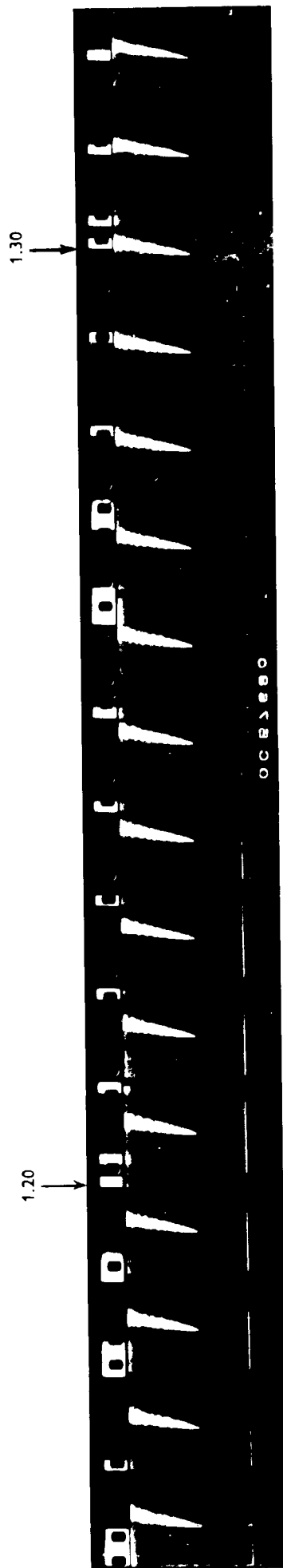


FIG.9. TYPICAL RECORDING (HIGH SPEED CINE CAMERA)



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